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Planning: Environmental and Lighting Systems, Museum of International Folk Art and the New Mexico Museum of Art

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This project had a dual focus in that energy efficiencies and improvements to preserving collections for the Museum of International Folk Art(MOIFA) focused on lighting issues in the Girard permanent exhibit wing. Investigations of the HVAC there were also made and important discoveries made. The major focus for this project at the New Mexico Museum of Art (NMMOA) was focused on the HVAC system controlling areas of the building housing collections and exhibit spaces.

This white paper will attempt to detail the project discoveries, issues and highlights. It is hoped that this sharing of knowledge will benefit the larger museum community.

Museum of International Folk Art (MOIFA)

Lighting

The Girard Wing contains approximately 100 individual internally illuminated exhibit cases. The types of light sources range from incandescent to fluorescent to neon. With the exception of replacement compact fluorescent lamps for many of the incandescent lamps, the case lighting in the Girard Wing has not been significantly modified since it was first installed in 1982 that time. The NEH-funded project needed to address the following:

- Cases are illuminated with line voltage fixtures. Old electrical wiring, and heat from fixtures, present a significant level of risk to the collections on exhibition within the cases.
- Most of the lighting is in the top of the case. Because of the location of the light relative to the objects, the top lighting is inefficient. Surfaces in the plane of the top light, barely or not at all seen by the public, receive excessive exposure, whereas the surfaces that can be seen by the public are often under-illuminated. Problems of excessive light exposure are magnified because the lights have no dimming control capability.
- The existing lighting fixtures are extremely energy inefficient for two reasons. The amount of lumens of light per watt is low compared to the current generation of LEDs. Also, the lamps give off light in all directions, so only a relatively small portion of the light illuminates the surfaces that need to be illuminated.

It is obvious that the existing fixtures and wiring needed to be removed, and replaced with energy efficient LED lighting fixtures. The new lighting plan underscores the importance of some of the less obvious advantages that LED lighting can offer. These advantages provide the museum with a greater range of flexibility and customization options by the end-user which can be implemented in a cost-effective manner.

- Many of the existing lights can be replaced with linear LED light fixtures. These fixtures consist of a string of LEDs placed within a small aluminum housing that can be made to custom lengths. Because of the small form factor of linear LED fixtures, they can be placed above the existing diffuse daylight, positioned close to the front of the case. In most instances, this placement increased the proportion of light falling on the visible surfaces of objects on display, providing a much more balanced viewing experience. It also reduced excessive light exposure to surfaces barely visible to the public and eliminated the waste of non-functional light output associated with undirected light sources.
- Linear LED light fixtures are generally designed as low voltage DC devices. This is an important consideration, since low voltage DC electrical installations operating at a low wattage do not require the type of restrictions associated with AC wiring, such as running

electrical wiring through conduit. Installation of low-voltage DC wiring does not have to be done by a licensed electrician. In many instances, the lighting fixtures and associated equipment such as drivers use quick connect plugs. Therefore, the installation of the LED fixtures within individual exhibition cases can be carried out by museum technicians rather than an electrical contractor. For this project, this was a very important consideration since many of the cases could be retrofitted with new LED lighting by trained museum technicians without fully de-installing the objects within the case.

- Each case light fixture will utilize a dedicated dimming module to control light intensity. Since LEDs are solid-state devices, they can be dimmed without a shift in color temperature.
- A range of color temperatures were evaluated. The choice came down to either 3000K or 3500K. It was determined that 3500K linear fixtures were generally preferred but could be modified with a color temperature filter in the event that a warmer color temperature is required for specific applications.

The existing lighting is now a mix of incandescent and an early Neon like fluorescent tube pre-cursor. The best estimate for this mixed lighting (and it is very, very bright) is about 15 watts per running foot of exhibit casework. There are about 350 running feet of casework. The best estimate that the original wattage was somewhat more than 5,000 watts for this exhibit. The new LED lighting runs about 2 watts per foot. A complete shift to LED lighting within the casework would change this situation to a total exhibit casework lighting load of 700 watts.

In addition to this energy savings is the real benefit of getting rid of ultraviolet and infra-red radiation from the exhibit. The current mix of incandescent and neon/early fluorescent lighting is rich in infra-red and has a not inconsiderable amount of ultraviolet radiation. By using high quality LEDs, the emission spectrum is restricted to visible light only and the color rendering vastly improved. A really solid win for this upgrade when you can improve the visitor experience as well as enhance the preservation of this permanent exhibit.

HVAC

At the time of this project the MOIFA facilities manager and the collection manager were monitoring the various internal environments using the HVAC Tracer Summit control system. There were no independent sensors or environmental data loggers.

During monitoring activities in support of this project and the MOIFA exhibit “The Color Red” one of the galleries showed a recurring period of extremely high humidity occurring between 8:05 a.m. and 9 a.m. on a daily basis. This Rh “spike” was usually in the range of 65 to 70% Rh, well in excess of the target 50% +-5%. This was in the early gallery conditioning stages of this exhibit and before any exhibits were installed. Being in the arid south west Conservation has determined that our collections needed to be kept at 35% +-5%. However, when exhibiting artifacts from much high Rh environments we sometimes elevate the entire gallery to the appropriate Rh. This gallery was being brought up to and equilibrated to the temporary 50% Rh regime.

Upon consulting the MOFIA facilities manager and collection managers their Tracer Summit control system was showing a steady 45% with none of the Rh spiking that the in gallery data loggers were showing. Further investigation showed that the museum guard staff were well aware of the humidity spikes.

The HVAC company under contract at that time to maintain the systems at MOIFA was called in and could not find any issue. However, when confronted with the data logger records they were able to determine that part of the HVAC control system was faulty. Upon further investigation by facilities staff and the HVAC contractor a particular pernicious situation was discovered. The main HVAC computer which provided the current picture and data for the Rh and temperatures within MOFIA was in effect no long communicating with the sub-computers controlling each of the HVAC units within MOFIA. The main system was reporting phantom information with no connection to what was really going on within the galleries and collection spaces. The sub-computer nodes controlling the individual HVAC units were working in a "default" mode which incorporated economizer settings. Economizer settings are used by HVAC system programmers to achieve energy efficiencies during the daily cycle. The cycle being used was one common with office buildings which have an effective occupancy of 8/5 (eight hours a day for five days a week). However, museums do not operate that way and the Chief Conservator as DCA Energy Manager had previously stipulated that all economizer settings were to be removed from the control systems. Museums with internal collection spaces operate on a 24/7 cycle (24 hours a day, seven days a week).

Bad environment information being reported that looks bad in not good but it is far worse to have a system reporting Rh and temp well within desired limits when it really isn't. This was the situation we discovered at MOFIA. If it were not for the data loggers deployed as independent monitors, we would never have discovered this. Nor would we have been able to provide the detailed day, date, time information that the HVAC contractor required to track down and eventually to eliminate the economizer setting.

This discovery caused us to doubt the condition of the entire system. Ensuing investigations uncovered serious mechanical faults. Repairs to mechanical HVAC components included: humidifier tanks, compressors, fan units and serious up rating of the pressure regulator and supply water lines for the museum. Additionally, all HAVC control systems were upgraded and re-integrated.

Lack of sufficient funds, insufficient knowledge and training in those responsible for maintaining what can be a very complicated control system places too much reliance on external HVAC contractors who are competing for lowest dollar maintenance contracts.

Once these errors were discovered, more knowledgeable facilities staff were brought in and effected repairs.

The cost of mitigating the above issues was $35,000 not including staff time and labor. Reflecting that the egregious state of the MOIFA environment controls went undiscovered for so long due

to the lack of third party environment data loggers, we will be installing new Wi-Fi enabled data loggers so that anyone who needs to can check the various internal environments from any internet enabled computer from location and can verify or not the accuracy of the building HVAC control system. This we feel is an extremely important improvement which should prevent this issue from ever going long undiscovered in future.
After comparing a few different Wi-Fi enabled Rh/Temp data loggers, a product made by the Lascar company was chosen and 26 Wi-Fi data loggers purchased. A functioning intranet is required for these units and the first installation type tried was to set up one host computer that all data loggers would report to via the local Wi-Fi network. After some months working with state Department of Information Technology (DoIT) and the data logger manufacturer, this approach was abandoned. We could never get consistent communication between data logger and the host computer when the data logger and host were in areas covered by different Wi-Fi nodes even though still on the same Wi-Fi network.

Instead what was found to work and work very well indeed was to use the "call home to ET" function. Using the internet capable local Wi-Fi network, the data loggers would reach out to the cloud server run by Lascar's affiliate "Files Through the Air". At first a test account for 5 data loggers was set up. After a significant trial period was successful, all data loggers were set up to report to the cloud. Only cloud account holders can access this information so it is presumed to be safe from unwanted prying or interference.

Advantages of this system are:

- It can be appropriately accessed by any computer with internet access
- Environmental data can be seen graphically or by data files and summary information is directly available
- Data logger settings can be set via this internet cloud server. These settings include:
    - Fahrenheit or Centigrade scale
    - Logging interval from a short one minute to many hours
    - Reporting interval from every 5 minutes (useful when setting up) to every 24 hours (which gives maximum battery life)
    - What to report
    - Alarms can be set for Rh, Temp, battery life, when to send email alerts and who to send them to (by entering which email addresses are to get the alarms/alerts)
    - A wait time for alarms can be set which can be useful if there is a door or window nearby the data logger. A wait time can be entered so that an alarm is sent just because there is a temporary draft from and the door opening and then closing.

This is our solution to providing inside vitrine environmental information. Our data loggers are in high demand for new exhibits as a result.

Cost of the data loggers was ca. $150.00 in early 2015 and all Wi-Fi connections were handled by conservation staff. DoIT staff provided the internet capable Wi-Fi network by piggy backing on the existing public access Wi-Fi although the networks we used were hidden and password protected.

New Mexico Museum of Art (NMMOA)
NMMOA's interior environment is the museum's primary preservation challenge. The historic building (constructed in 1917) was not designed for current museum environmental standards, and NMMOA continues to seek a solution to its climate needs.

Early project team discussions highlighted the desirability of bringing in a "Commissioning Agent" as part of the team. This was done by sub-contracting through the overall engineering consultant who would then provide appropriate interpretation of the commissioning agent's findings and ensure they were integrated within the engineering report.

A commissioning engineer is a specialist in building systems and whose goal is to ensure that all systems operate correctly and as planned. Such an engineer is capable of looking deep within the control code of modern HVAC systems and comparing what the system is supposed to do and what the building environment really is. Inconsistencies can be determined and solutions developed. Commissioning engineers are used after a building has been constructed and is in the final "tuning" phase prior to being released as fully completed. They are also used when systems are old, or are in need of serious repair. They provide a level of expertise and knowledge far in excess of what the usual HVAC control contactor is capable of.

The HVAC study was to:

- Monitor and analyze the temperature and humidity systems throughout the monsoon and winter seasons in order to identify whether the existing mechanical system can maintain the set points required by the exhibit collections
- Review existing HVAC equipment and controls to determine options for achieving the following goals:
    - The ability to maintain an acceptable temperature and relative humidity range to preserve museum collections.
    - Maintain an adequate environment to meet the comfort requirements of museum staff and visitors.
    - Methods for realizing energy savings while achieving the twin goals of preservation and human comfort.
- Provide recommendations on modifications regarding HVAC equipment repairs, upgrades and replacement.
- Provide recommendations on modifications regarding system controls including sequences of operation, set points, control equipment and/or software.

After the HVAC system and controls was evaluated, it was the intent of this project to have the commissioning engineer suggest and make any modifications to the sequence of HVAC operations needed to ensure maintenance of the desired Rh and Temp set points. During the initial system analysis, the commissioning engineer identified multiple issues with the system that would prevent the system from operating properly. These issues effectively prevented completion of the study as planned.

- It was discovered that the air handler unit components were damaged and needed to be

repaired or replaced.

- The space sensors were not accurately reporting the space conditions to the controls system.
- It was not possible to access the embedded sequences of operation or reprogram the proprietary HVAC control system that had been installed by Trane several decades ago. At present, system controls modifications are limited to readjustment of set points.

In order to continue with this project estimates were obtained and funding sought to carry out the needed repairs. The spreadsheet inset below shows the work accomplished.

Capital Repairs to NMMOA	
Replace Air Handler	$167,554.24
Repairs to Steam Boiler	$4552.87
Replace compressor and on Trane chiller	$14,470.08
Replace pressure switch and gauges on Trane chiller	$1,056.00
Repair leak on Trane condenser	$4,547.12
Surge protectors	9.868.00
Engineering and scope of work for air- handler proposal	$2,683.88
Total	**$194,864.19**

This was truly inspirational that a cash strapped system still dealing with the effects of the depression and the loss of oil and gas revenues would dedicate emergency funds for these repairs. Unfortunately, the bottom of the funding was found before all the necessary repairs were made. Critical portions of the HVAC control system (the modules controlling sensors and major HVAC units) were not replaced. These modules along with other parts of the system were damaged by a nearby lightning strike.

Protection to the building systems from electrical faults such as lightning strikes had not been installed and thus critical building systems were damaged. Lightning protection has since been installed. A major take away from this project is protect your building systems from electrical faults such as lightning strikes. Systems can range up to $35,000 depending upon system size, etc. Protecting HVAC systems that are typically 10 to 15 times that and which safeguard artifact and artwork collections worth many millions would seem to be something we should do without thinking. This in a state which is considered by some to be the 2nd highest in lightning strikes in the continental U.S.A.

Due to our exposure to niceties of having the expertise of an engineering firm with a commissioning agent we decided to using state funds to have the replacement HVAC system designed by the museum HVAC contractors evaluated for suitability. This was the best $2,683.88 spent on this project as the new replacement system was found to be fatally flawed. Fine as a standalone HVAC unit when it was integrated within the museum structure and HVAC system it would work against the rest of the system which had been designed to work within this historic building. Once the recommended changes to the HVAC unit design were made, it was ordered, received and installed and up and running.

This new unit had the same capacity and components as the unit it replaced. The system was not redesigned or upgraded with new accessories. The new air handler unit operated in the exact same way as the previous unit since it is controlled by the existing control system. Because the existing system RH and temperature sensors may not be reliable, third party data loggers that do not rely on communication with the frontend computer unit were installed. One data logger was installed in each exhibit space. The data loggers recorded the space temperature and humidity information over the entire timeframe of the study. That information was then downloaded onto the computer and trended for the period in which it was recorded.

Environmental data was collected and compiled by the commissioning engineer and incorporated into a facilities assessment report. M&E provided an overview and summary of this report.

The lightning damaged HVAC master controller modules made it impossible to access the controlling computer sequence of operations.
Recommendations from the engineering report include these:

- Replacement of existing equipment with more energy efficient equipment is a prime opportunity for realizing significant energy savings
- Modification of existing sequences of operation. It was not possible to review the embedded sequences within the current control system for the Old Wing in order to provide recommendations on specific improvements to enhance performance or achieve energy savings. However, it is clear that significant improvements can be achieved once the current control system can be accessed, upgraded or replaced.

The staff is aware of the need to improve lighting conditions within many of the galleries. In some instances, this may require the redesign of existing lighting systems such as the relocation of track lighting hardware. When this takes place, new LED fixtures will be considered. In the short-term, interchangeable LED replacement lamps with a relatively short-payback have been suggested as a viable option.

Much extremely valuable knowledge was gained during this project. Even though we have not increased the accuracy of maintenance of environmental set points as desired at the NMMOA we have learned why that is not so. We have also corrected many systemic faults and the HVAC system is better than before. We intend to continue to seek funding to replace the HVAC control

system as recommended by the consulting engineers.

Long Term Impact

This study is having a profound impact on how DCA is looking at its aging Museum infrastructure. Previously, we have relied nearly entirely upon HVAC contractors to provide repairs, new HVAC units and controls without seeking outside engineering expertise to see if the proposed repairs and replacements were what was really needed. This project will save many hundreds of thousands of dollars over the next few years. The small sum of money spent to have the Commissioning engineer and M&E Engineering to review the HVAC replacement proposed by the HVAC contactor shoed that the hundred-thousand-dollar unit as designed was not only insufficient but would introduce serious issues with the larger HVAC system it was to fit into within the NMMOA. These issues were serious enough to defeat the larger system as it was designed to fit within the historic space of the NMMOA. The HVAC contractor ignored this necessity and did not understand the particular needs of this building. Less than three thousand dollars was spent on the engineering review and it saved more than one hundred thousand dollars and ensured that the installed system provided the needed environment.

The concept of using a commissioning engineer to critically analyze the current HVAC performance and control system within our museums and to determine what were the real issues needing addressing was unknown prior to this project. Rather than an expensive blind “shot gun” approach to addressing museum HVAC issues as was our previous practice, we now have a way to know what to replace/repair and an assurance that it will operate in the manner needed once it is installed.

Thirdly, the need to have a set of independent environmental monitors in place has been identified. If you don’t know your HVAC system is lying to you, you can’t fix it. A system of Wi-Fi data loggers is being implemented in several of the Santa Fe museums within DCA, installed, cared for and monitored by the Conservation unit remotely in the “Cloud”. Email alerts are sent out automatically now when set points for Rh and Temp are broached.

Lastly, the introduction of energy efficient, high color rendering LED fixtures suitable for in case work installation will be used in future exhibit designs and retrofitted through the state system as possible.